FRED Reports

Kwiniuk River Salmon Enhancement Feasibility Study

by
Frederic R. Kraus
and
Carl Kalb

Number 115

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

SPECIAL REPORT TO NORTON SOUND ECONOMIC DEVELOPMENT CORPORATION

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Alaska Department of Fish and Game
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ABSTRACT

During 1990-1991, several sites in the vicinity of Elim were investigated to evaluate the potential of several types of fisheries enhancement strategies. Water quality and quantity were measured. Water temperatures were monitored with recording thermographs and native fishes sampled.

Of the sites investigated, the Kwiniuk River study area appears to have good potential for a permanent salmon production facility, but it requires more detailed studies. Chum salmon, *Oncorhynchus keta*, and pink salmon, *O. gorbuscha*, should be considered unless additional coho salmon, *O. kisutch*, rearing habitat can be identified. Three sites were identified that may have potential value for streamside-incubation boxes. Finally, a regional fisheries planning team should be established to coordinate the development of any fisheries enhancement plans with management considerations. Other considerations and fisheries enhancement options and planning assumptions are also presented.

KEY WORDS: Enhancement, Norton Sound, site survey, water quality, water temperature, and volume.

INTRODUCTION

The North and Northwest Mayors' Conference and Norton Sound Economic Development Corporation have expressed a desire to enhance salmon stocks in Norton Sound drainages as a means of promoting economic development through increased salmon catches. The Norton Sound Economic Development Corporation and Alaska Department of Fish and Game (ADF&G), Division of Fisheries Rehabilitation, Enhancement and Development (FRED) have agreed to conduct baseline biological studies in the Kwiniuk River drainage, near Elim, Alaska, to determine the feasibility of salmon enhancement through construction of a permanent hatchery facility.

Objectives of these studies were to collect and analyze physical, chemical, and biological data from the site, including water flow, temperature, dissolved oxygen, water chemistry, turbidity, and juvenile fish trapping. In addition, an assessment of potential salmon donor sources will be discussed.

METHODS

A preliminary site visit was conducted on 27 February 1990 by Mr. David Gaither, FRED Division Regional Senior Fish Culturist (retired). Field biologists from the Big Lake Hatchery visited the Kwiniuk River drainage on 3 October 1990, 15 April 1991, and 25 June 1991 to assess the feasibility of salmon enhancement in the Elim area (Figure 1). During each visit, physical, chemical, and biological data were collected for later analysis. Information gathered included water quality and flows, as well as temperatures, dissolved-oxygen concentration, and turbidity. Sites studied were located approximately 10 trail miles northwest of Elim and included three specific areas, all located in close proximity to one another. For this report, these three sites will be referred to as the Kwiniuk River, Hot Springs Pool, and Hot Springs Stream. Four potential alternative incubation sites were also visited during the 25 June 1991 visit. These included Corral Creek, Iron Creek, Elim Creek, and the Elim City Well.

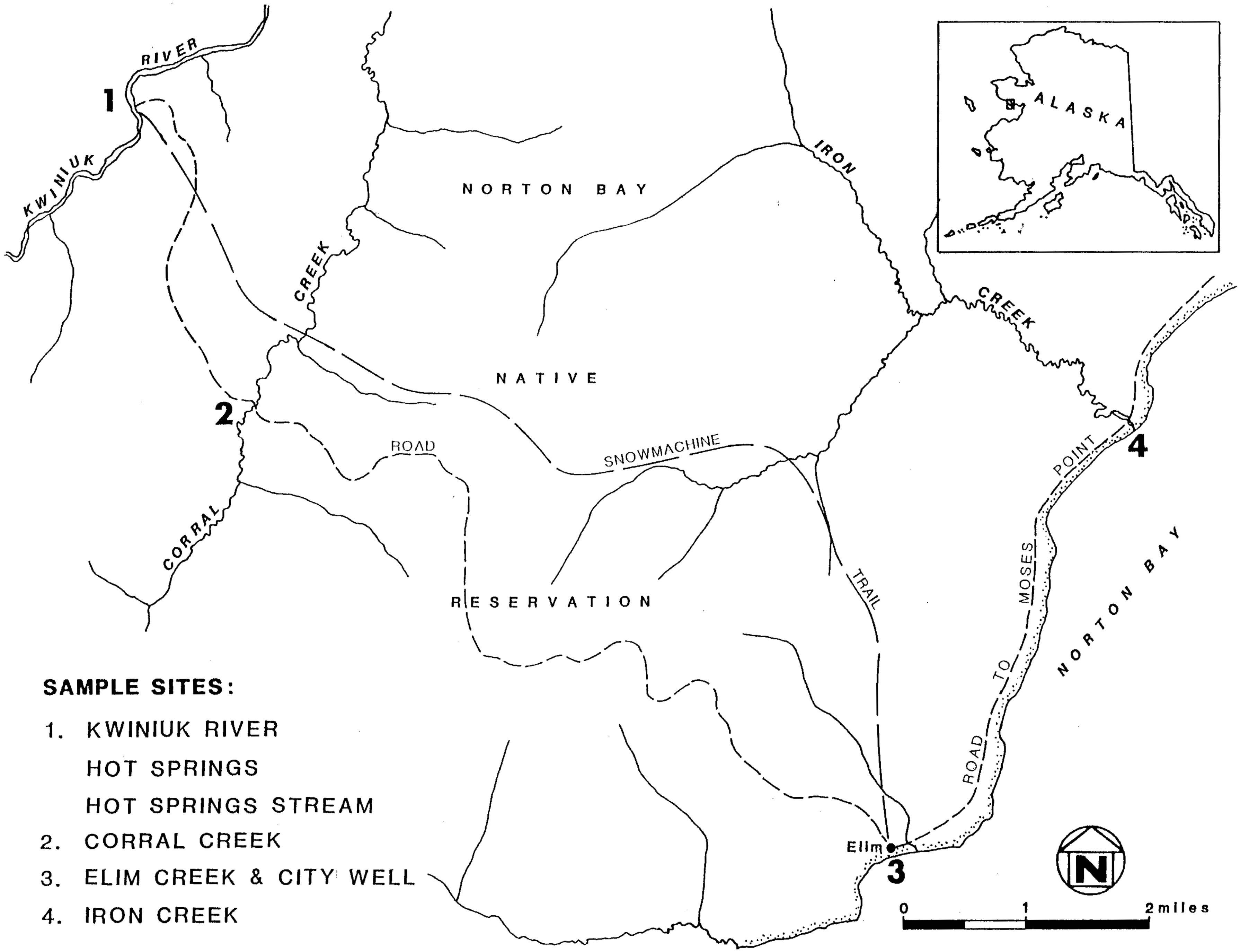

Figure 1. Sampling sites in the vicinity of Elim for the Kwiniuk River Enhancement Feasibility Study.

SITE DESCRIPTIONS

The Kwiniuk River flows through a narrow valley, the nearest ridges rising gradually to a height of 490-560 ft (150-170 m). The vegetation is predominately spruce and alder on the surrounding hills with willow and poplar along the riverbank and gravel bars. River width averages 82 ft (25 m) and water depth averages 1.6 ft (0.5 m). There are several islands that divide the river into three separate channels. Gravel size is variable, from small to large. River-gradient calculations yielded a 2.5-ft (0.8-m) drop in 300 ft (91 m). The Kwiniuk River drainage produces all five species of Pacific salmon, with chum and pink salmon the predominant species. There are also resident populations of Arctic char, *Salvelinus alpinus*, Arctic grayling, *Thymallus arcticus*, whitefish, *Coregomus sp.*, and sucker, *Catostomus sp.*

The river is reportedly stable with little flooding. High-water periods do occur in the spring during breakup, at which time access to the site is possible via jetboat. Currently, access is by snowmachine during the winter and all-terrain vehicle during the summer. The City of Elim has constructed a narrow road from the city to the bank of the Kwiniuk River. The city intends to further improve the road to create an all-weather surface with year-round access.

The Hot Springs Pool site is comprised of two pools: The smaller, upper pool is approximately 755 ft (230 m) from the Kwiniuk River and around 49-ft (15 m) higher in elevation, while the lower pool has a rock dam constructed across the downstream side to create a bathing area. Both pools have sandy bottoms with a slight odor of sulphur. The hot spring water seeps from both pools and several other points downhill, eventually forming a single stream. A green algae is present in both the upper pool and stream, but not in the lower pool, probably because of frequent bathing activity in the lower pool.

The resultant stream from the pools is joined by a cooler groundwater stream approximately 328 ft (100 m) from the pool. The now cooler Hot Springs Stream continues along the base of a hill and eventually drains into the Kwiniuk River, 2,008 ft (612 m) from the pools. The stream is separated from the river by a low brush-covered gravel bar, 98-197-ft (30-60 m) wide, and joined by four additional feeder streams before entering the Kwiniuk River. The Hot Springs Stream sampling site is located 1,500 ft (457 m) downstream from the pools, just above the point where the second feeder stream enters the Hot Springs Stream.

During the winter, the Kwiniuk area was blanketed by at least 3 ft of snow. The Kwiniuk River was ice- and snow-covered with some exposed water sections. Flowing water was present. The Hot Springs Pools and Hot Springs Stream were not frozen.

Corral Creek is located approximately 6 miles (9.7 km) northwest of Elim where it is crossed by the road to the Hot Springs and Kwiniuk River area. It is a clear-water stream with good gravel substrate suitable for salmonid spawning activity. It is reported that this stream remains relatively ice-free during the winter. Corral Creek drains into the Kwiniuk River approximately 2 miles (3.2 km) downstream from the Hot Springs study site. The area is surrounded by spruce forest and is situated between two large hills. Stream gradient appears to be sufficient to supply adequate head to feed streamside-incubation boxes. There is some salmon-spawning activity in this creek during the fall.

Iron Creek is located 5 miles (8 km) northeast of Elim and is accessible year-round by an all-season road that eventually ends at Moses Point, 10 miles (16 km) away. The creek passes under the road through a large culvert. A large pond-like slack-water area drains through the culvert with resultant water creating a fast-moving stream on the other side with good gradient. Scouring action created by water leaving the culvert has caused the formation of several deep pool areas on the stream edge. Iron Creek drains into Norton Bay, approximately 0.25 miles (0.4 km) below the culvert. Vegetation consists primarily of alder and spruce trees. There are naturally occurring returns of coho and pink salmon stocks in this stream.

Elim Creek flows through the village of Elim and serves as an emergency water supply. This small creek drains into Norton Bay, approximately 0.25 miles (0.4 km) from the city well-pump building. Year-round access is available. Stream size averages 15-ft- (4.6 m) wide and 1-ft- (0.3 m) deep. Elim Creek meanders through a wet, brushy area before passing through the village to salt water. There are apparently no, or very few, salmon that return to this creek. Several reaches of the creek contained garbage and other debris.

The City of Elim pumps its water from a spring-fed well located in the village and in close proximity to Elim Creek, which provides the backup water source. There is an enclosed pumphouse building with a sump from which water is pumped to storage and distribution tanks. Drinking water is generally abundant year-round with the exception of occasional winter shortages. The pumphouse building is readily accessible.

TEMPERATURE

A battery-operated Omnidata® Datapod (Model 212) timed temperature-recording device was placed adjacent to the upper Hot Springs Pool on 3 October 1990. The datapods were programmed to record average, maximum, and minimum ambient air and water temperatures once every 24 hours. This information was stored on a computer microchip in the datapod. The individual microchip was recovered for later processing on 15 April 1991. Equipment was then removed due to vandalism. The datapod ceased data collection on 13 January 1991.

The datapod was mounted inside a weatherproof container (ammunition box) attached to a steel fence post that had been driven into the ground. Air and water temperature cables were taped to the steel post. The air-temperature thermistor was secured within a 6-in (150 mm) section of 1/2-in (12.5 mm) PVC pipe to protect it from direct solar radiation. This pipe was fastened to the fence post directly below the ammunition box. The water temperature

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thermistor was secured inside a protective container and placed under a rock in the upper Hot Springs Pool. Any exposed cable was covered to prevent potential animal and/or human tampering. Excess cable was coiled inside the ammunition box. A desiccant capsule was placed inside the battery compartment of the datapod before being sealed with electrical tape. More desiccant was then placed in a cup inside the protective container before it was closed.

One Ryan® J-180 battery-operated chart-recording thermograph was placed in the Hot Springs Stream on 10 October 1990 by a village resident; equipment difficulties prevented the placement of the thermograph during the 3 October 1991 visit. The thermograph was placed in an enclosed, protective container and held in place on the bottom with a large rock. The original thermograph was retrieved and replaced on 12 February 1991 with a Ryan J-90 thermograph. Rough handling during the transport phase resulted in equipment failure prior to installation of the replacement thermograph. During the 15 April 1991 visit, the problem was corrected and the thermograph replaced. Temperature data were not available from 12 February 1991 through 15 April 1991 for the Hot Springs Stream. The Ryan J-90 thermograph was removed from the Hot Springs Stream on 25 June 1991.

All temperature-recording equipment was calibrated prior to field installation, with the exception of the Ryan J-90 thermograph that was calibrated upon retrieval. No water temperature-recording equipment was placed in or adjacent to the Kwiniuk River because it could not be retrieved during the winter and it was expected that any equipment in the river would be lost or destroyed during spring breakup. Temperature data that was stored on the microchips were downloaded to computer diskette using a Omnidata Model 217D Reader.

TEMPERATURE UNITS

Various important chum salmon egg-developmental stages were estimated for the Hot Springs Stream using stream-temperature data and accumulated thermal units (ATU). One temperature unit is defined as 1°C for a 24-hour period.

WATER QUALITY

Chemistry

Water-quality information was collected during each visit to the Elim area sites. Individual site samples were collected in two, 1-liter plastic bottles and sent to the ADF&G, FRED Division Limnology Laboratory in Soldotna, Alaska, for general and nutrient analyses. A portion of each sample was forwarded to Elemental Research Industries in Vancouver, British Columbia, Canada, for metal-ion analyses. Detailed results of water-chemistry tests were received and compared to several salmonid water-quality-requirement criteria.

Dissolved Oxygen

Dissolved-oxygen levels were measured during each visit to Elim area sites using the Winkler Titration Method. A 6.7-oz (200 ml) sample was titrated and analyzed on site with "Hach" digital- or drop-titration kits.

Turbidity

Turbidity measurements were performed on samples in the field during initial site visits using a Lamotte® Chemical Model 2008 turbidity meter. Turbidity measurements were also obtained through water samples analyzed at the ADF&G, FRED Division Limnology Laboratory and included in the general water-quality report. No field-turbidity tests were performed in Corral, Iron, or Elim Creeks, or from the city well-water source. This information will be available from upcoming ADF&G, FRED Division Limnology Laboratory analysis reports from water samples collected at these locations, except Iron Creek.

WATER QUANTITY

Stream velocities were measured during initial study site visits using a Marsh-McBirney® flow meter. Actual stream discharges were calculated using the U.S. Geological Survey Midsection Method. The Robins-Crawford method for estimating approximate discharge was used during all subsequent visits and during site investigations conducted on 25 June 1991.

The discharge was calculated according to the formula:

$$Q = \Sigma(d * w * v)$$

where: Q = discharge
d = average depth of a stream segment
w = width of a stream segment
v = average water velocity of a stream segment

From the total discharge, it is possible to calculate egg-incubation capacities through the use of a formula described by McLean and Raymond (1983). The following formula was derived for single-pass systems and assumes a required volume of 100 gal (378 liters) per 1 million eggs.

$$C = Q/378$$

where: C = incubation capacity in millions of eggs

Q = total discharge in liters

JUVENILE FISH TRAPPING

Juvenile fish traps were fished in the Kwiniuk River and Hot Springs Stream to evaluate the presence and species of young resident salmonids. These traps were set on 25 June 1991 and retrieved approximately 16 hours later on 26 June.

RESULTS AND DISCUSSION

It has been proposed that a permanent salmon hatchery may be an ideal method by which to enhance the Kwiniuk River and serve as a central-incubation system for rehabilitating or developing salmon runs in Norton Sound. To successfully incubate and possibly rear salmon eggs using this technique, a site must meet several requirements:

1. Water-supply temperature and quality must be suitable.
2. Adequate water flow and possibly "head" for gravity feed to deliver water to the hatchery.
3. Access to the site for hatchery personnel and equipment.
4. Access to brood stock by hatchery personnel.
5. Protection from freezing conditions.
6. Protection from flooding.
7. Local fish-processing capability.

Each of the above criteria will be addressed in this discussion as they relate to the Kwiniuk River area.

The three study sites in the Kwiniuk River area each have greatly differing water-temperature regimes; this would indicate that water-temperature manipulation could be considered.

Water temperatures in the mainstem Kwiniuk River were 37.4°F (3.0°C) on 3 October 1990, 32.9°F (0.5°C) on 15 April 1991, and 53.6°F (12.0°C) on 25 June 1991. It is most likely that the Kwiniuk River exhibits similar water-temperature patterns as those found in nearby lower Yukon River drainages (McLean and Raymond 1983). These include long periods (6 months or more) of 32.0°F (0.0°C) water temperatures. These temperatures represent a challenge for hatchery operation. A water-temperature-monitoring station should be installed in this system for at least one year.

Hot Springs Pool temperatures were quite constant in about the 104.0°F (40°C) range. These temperatures are obviously unacceptable for direct culture of salmon. It may, however, be possible to use this heated water to operate a heat exchanger to warm the colder water from the Kwiniuk River. This warm-water resource is 49-ft (15 m) higher in elevation than the river, so gravity may be employed to deliver warm water to heat exchangers, if enough volume were available.

The Hot Springs Stream water temperature averaged 44.2°F (6.8°C), with maximum 48.2°F (9.0°C) and minimum 40.6°F (4.8°C) from 11 October 1990 through 12 February 1991, and averaged 51.8°F (11.0°C), with maximum 73.4°F (23.0°C) and minimum 41.9°F (5.5°C) for the period 15 April 1991 through 25 June 1991 (Table 1). Temperature fluctuations in this small stream of 33.8°F (2.0°C) to 44.6°F (7.0°C) over a 24-hour period were not uncommon. If chum salmon eggs were incubated in the Hot Springs Stream water starting in October, fry emergence would occur in late February or early March.

Water-quality data suggest that water at all three Kwiniuk area sites is suitable for culture of salmon, except for the Hot Springs Pool, which had high concentrations of potassium and

Table 1. Average stream and air temperatures (°C) and ranges for Elim area test streams, 3 October 1990 through 25 June 1991.

		Days	Hot Springs Pool			Hot Springs Stream		
			Mean	Max	Min	Mean	Max	Min
October								
1-10	Water	10	40.8	41.5	39.5			
	Air		3.1	11.0	-1.5			
11-20	Water	10	40.4	42.0	40.0	7.9	9.0	7.0
	Air		-2.9	8.0	-18.5			
21-31	Water	11	40.3	41.0	40.0	7.0	8.5	6.2
	Air		-7.9	1.5	-20.0			
November								
1-10	Water	10	40.3	41.5	40.0	6.9	8.5	5.6
	Air		-12.0	2.0	-28.0			
11-20	Water	10	40.5	41.0	40.0	7.6	8.3	6.7
	Air		-7.1	0.0	-22.0			
21-30	Water	10	40.2	41.0	40.0	6.2	7.5	5.5
	Air		-25.0	-8.5	-41.5			
December								
1-10	Water	10	40.2	41.5	40.0	6.0	7.0	5.3
	Air		-23.4	-16.5	-39.5			
11-20	Water	10	40.4	42.0	40.0	6.8	8.5	5.5
	Air		-19.6	0.0	-42.0			
21-31	Water	11	40.4	41.5	40.0	6.5	8.2	5.5
	Air		-14.8	-1.0	-35.0			
January								
1-10	Water	10	40.5	41.0	40.0	6.8	8.0	5.0
	Air		-16.4	-1.5	-45.5			
11-20	Water	10	40.2	41.0	40.0	5.5	7.6	4.8
	Air		-42.8	-34.0	-47.0			
21-31	Water	11				7.4	8.1	5.8
	Air							

-continued-

Table 1. Average stream and air temperatures (°C) and ranges for Elim area test streams, 3 October 1990 through 25 June 1991.

		Days	Hot Springs Pool			Hot Springs Stream		
			Mean	Max	Min	Mean	Max	Min
February								
1-10	Water	10				6.1	7.6	5.5
	Air							
11-20	Water	10				8.0	8.0	8.0
	Air							
April								
16-20	Water	5				11.2	13.5	8.5
	Air							
21-30	Water	10				12.0	16.5	9.0
	Air							
May								
1-10	Water	10				9.8	16.0	6.0
	Air							
11-20	Water	10				7.0	10.0	5.5
	Air							
21-31	Water	11				8.3	12.0	6.0
	Air							
June								
1-10	Water	10				12.1	18.0	7.5
	Air							
11-20	Water	10				14.2	22.0	9.5
	Air							
21-25	Water	5				17.0	23.0	12.0
	Air							

other compounds (Tables 2 and 3). The poor water quality found in the Hot Springs Pool would prevent direct mixing of this heated-water source with a colder stream or river supply for hatchery incubation or rearing of salmon.

The Kwiniuk River is probably capable of sustaining a production hatchery facility. Flows were nearly 110,000 gal/min (7 m^3/sec) in October (Table 4). Winter, spring, and summer flows were not measured. Flows will be measured in 1991/1992.

The Hot Springs Pool is unacceptable for direct culture of salmon. In addition, discharge from the pools was a constant 30 gal/min (.002 m^3/sec). Consequently, a larger volume of heated water would be required if it were to be used as a heat-exchange source.

The Hot Springs Stream would be capable of incubating 1.65 million eggs at the minimum recorded flow of 165 gal/min (.01 m^3/sec) during the early spring site visit. The relatively warm temperatures, however, would result in early emergence of the fry.

Access to the site should be excellent if plans to build an all-season road are carried out.

There appears to be healthy returns of chum and pink salmon as well as smaller numbers of coho and chinook salmon present in the Kwiniuk River drainage. Brood-stock source does not appear to be a problem; however, disease histories and run timing as well as spawning periods must be established.

Juvenile fish traps set in the Kwiniuk River and Hot Springs Stream caught no salmonids, but there were many sightings of salmonid fry in both systems near the trapping locations.

There was flowing water throughout the winter at the three Kwiniuk area study sites and, except during spring thaw, the area appears to experience minimal flooding.

During the 25 June 1991 visit to the Elim area, four additional sites were visited to determine the potential for streamside incubation facilities:

Table 2. Acceptable water-quality standards for rearing fish.[a/]

Parameter	A	B	C	D	E
Alkalinity	20		20-200	120-400	15
Aluminum	0.01	0.01			0.1
Ammonia	0.02	0.0125	0.012	0.0125	.05 N
Cadmium (alk<100)	0.0005	0.0005		0.0004	0.0003
(alk>100)	0.005	0.005		0.003	
Calcium	52		52	4-160	
Chromium	0.03	0.03			0.04
Copper (alk<100)	0.006	0.006	0.006		0.002
(alk>100)	0.03	0.03	0.03		
Dissolved Oxygen	5	7	5	5	11.2
Iron	0.1	0.1	1	0.5	0.3
Lead	0.02	0.02			0.004
Manganese	0.01	0.01		0.01	0.1
Mercury	0.2			0.002	0.0002
Nitrite	1	0.1	0.55	0.15	.015 N
Nickel	0.01	0.01			0.045
pH	6.7-8.6	6.5-8.0	6.7-9.0	6.5-8.0	7.2-8.5
Potassium	5	5			
Selenium	0.01	0.01			0.05
Silver	0.003	0.003			0.0001
Turbidity					
Zinc	0.005	0.005	0.04	0.03	0.015

A: Daily, J. P. and P. Economon, 1983.
B: Fish Culture Manual, ADF&G, FRED Division, 1983.
C: Wedemeyer and Wood, 1974.
D: Piper, G. P. et al., 1982.
E: Sigma Environmental Consultants and DFO Canada, 1983.

[a/] From Aquaculture Class. 1988. Water quality laboratory mimeo. Malaspina College. Nanaimo, B.C., Canada.

Table 3. Water-quality parameters and test results for Elim area test locations, 3 October 1990.

Parameter	Kwiniuk River	Hot Springs Pool	Hot Springs Stream
Alkalinity	34	0.2	15
Aluminum	0.0078	0.06	0.037
Ammonia	0.0082	0.0522	0.0103
Cadmium (alk < 100)	0.00025	0.0001	0.00025
(alk > 100)			
Calcium	13	180	40
Chromium	0.00057	0.0037	0.00057
Copper (alk < 100)	0.0014	0.01	0.0045
(alk > 100)			
Dissolved Oxygen	14.7	3.5	13.3
Iron	0.031	0.094	0.11
Lead	0.00014	0.0003	0.00024
Manganese	0.0011	0.011	0.011
Mercury	0.00019	0.00013	0.00013
Nitrite	0.003	0.0002	0.001
Nickel	0.00083	0.03	0.0016
pH	7.3	8.6	7.3
Potassium	1	18	4.9
Selenium	0.0011	0.043	0.0067
Silver	0.00004	0.00015	0.0001
Turbidity	0.4	0.4	0.6
Zinc	0.0067	0.006	0.0097

Table 4. Stream flows (gal/min) and incubation capacity for Elim area test locations, 3 October 1990, 15 April 1991, and 25 June 1991.

	Hot Springs Pool[a]	Hot Springs Stream		Kwiniuk River	
	Flow	Flow	Capacity (millions)	Flow	Capacity (millions)
3 October 1990	30	315		109,788	(6.9 m^3/sec)
15 April 1991	30	165	1.65	[b]	Production
25 June 1991	30	100?			

[a] Unsuitable for salmon culture.
[b] River width and snow cover did not allow stream-flow measurements.

1. Corral Creek water temperature on 25 June 1991 was 50.9°F (10.5°C). This fast-flowing, clear-water stream had flows estimated at 1,000 gal/min (.06 m^3/sec). It appears that gradient is sufficient to supply enough head to streamside incubators.
2. The presence of several large pools and large quantities of water as well as close proximity to Elim and salt water make Iron Creek a candidate for possible chum or coho salmon streamside-incubation activities. Water temperature on 26 June 1991 was 46.4°F (8.0°C), pH was 6.8, and the dissolved-oxygen level was 13.8 ppm. Flow was estimated at 1,500 gal/min (.09 m^3/sec). The water-temperature regime in this system is unknown; however, the creek reportedly remains ice-free during the winter. The gradient appears to be sufficient to supply head to streamside boxes.
3. Elim Creek may be an ideal location to establish a small chum salmon streamside incubator in conjunction with an in-school aquarium incubator. It would then be possible for students to understand the development of eggs in their streambox by adjusting a refrigeration unit to mimic stream temperatures. Stream cleanup and fish habitat improvement projects may also be initiated. Water temperature in Elim Creek was 40.1°F (4.5°C), pH was 7.8, and the dissolved-oxygen concentration was 12.0 ppm. Flow was estimated at 720 gal/min (.04 m^3/sec) with adequate head to supply water to a streamside box.
4. The Elim City Well Spring experiences periods of low flow during the winter; therefore, it would be unadvisable to consider this spring as an incubation-water supply. This water might be used, however, directly from the spring as a cold-water source for classroom incubation projects. The water is eventually chlorinated and distributed throughout the village. This spring-fed well water never freezes and exhibits constant water temperatures of 34.7°F (1.5°C). The pH was 7.8 and the dissolved-oxygen concentration was 7.0 ppm.

Water samples were collected from Corral and Elim Creeks and from the city well. No samples were collected from Iron Creek. These samples have been forwarded to the FRED Division Limnology Laboratory in Soldotna for analysis. No data were available at the time this report was written.

Water-temperature data from Iron and Elim Creeks as well as from the city well will be collected and recorded weekly by a local village resident throughout the summer of 1991.

There are fish-processing facilities at Moses Point located at the mouth of the Kwiniuk River, but marketing of commercially caught salmon has been difficult. In some years, the catch has spoiled because it could not be sold. Fish buyers reportedly may not come to the southern Seward Peninsula because of small catches of low-value fish, such as chum and pink salmon. It is the opinion of members of the city government that processors might return to the area if more fish were available for harvest. More fish should not be produced unless this assumption is verified. Actual value of proposed enhancement fish to fishermen should also be determined.

Production Alternatives

The following are strategies that may be available to increase fish production:

Strategy	Method	Advantages	Disadvantages
Local hatchery	- Kwiniuk River Use heated water from Kwiniuk Hot Springs	- Accelerate development rate of fry - Access to brood stock - Reasonable site access - Heated water capabilities	- May be limited by amount of heated water - More remote than potential streamside sites - Higher production cost
Incubation boxes	- Install boxes in free-flowing springs	- Simple - Inexpensive	- Small scale - Remote from brood stock
Norton Sound Central Incubation Facility (CIF)	- One large facility with a number of stocks for outplanting	- Support many locations - Share costs - Design new fisheries	- May need new fisheries - Remote from brood stocks - Transport fry for release
Net-pen rearing	- Rear fry in estuarine net pens	- Increased survival rate after release - Design new fisheries - Accessibility - Good combo with CIF	- Transport fry to pens - Donor stock selection

Another consideration that must be discussed entails developing a new water source, such as pumped well water. This may provide an excellent source of water for a fish hatchery, but it may be very expensive. The next step in the planning process must also include identification of one or more reliable brood stocks. In addition, a crucial part of the planning process must include a harvest plan that is developed in association with any enhancement plan. A special harvest area must be identified through a regional planning process that will not interfere with wild stock-management strategies. Planning assumptions that may be useful are included in the Appendix.

RECOMMENDATIONS

1. The Kwiniuk River study area requires more study but appears to have good potential for a permanent salmon-production facility. There may be a more cost-effective means of producing fish in the same drainage, and all options should be reviewed. Other potential enhancement sites visited around the Elim area should be investigated further for streamside projects, including recently visited sites.
2. Healthy returns of Pacific salmon and abundant resident salmonids already exist in the Kwiniuk River drainage and other local streams. Chum and pink salmon should be the only species considered for initial enhancement purposes in the Kwiniuk drainage, unless long-term-rearing facilities are developed. Coho salmon fry may be introduced into the Kwiniuk drainage if rearing areas are not fully utilized. Rearing habitat for coho salmon may be a limiting factor. This area will require more investigation. Competition and predation among wild and hatchery stocks must be minimized. Adequate brood stock should be available.
3. The ability of local processors to sell commercially caught salmon to buyers must be assessed and the value of produced fish to fishermen determined. Salmon prices have fallen drastically recently. Is it worth producing more low-value species, such as

chum and pink salmon? Can enough fish be produced to actually increase fishermen's income substantially?

4. Water temperatures and flows will be taken in the Kwiniuk River during the winter of 1991/1992. The Hot Springs Pool may be a good source of heated water for temperature manipulation, if more were available. At present, the quantity of heated water flowing from the springs is not sufficient to heat water for a production facility and should not be mixed directly with a hatchery cold-water source.
5. Three of the four sites visited during the 25-26 June 1991 visit have potential for streamside incubation projects, either educational or productional. Additional studies will be required. A test unit should be placed in one of the streams to determine the effects of possible 32.0°F (0.0°C) water on salmon eggs during the incubation phase. Streamside boxes should not be established in other streams until design, installation, and operational techniques are tested. This technology has not been tested in arctic environments.
6. A regional planning team should be established and work begun on a Norton Sound regional salmon plan. This is the vehicle for coordination between fishermen, the public, and ADF&G on the development and management of fisheries enhancement programs.

Other items not addressed in this report that must be considered prior to commencement of any enhancement program include:

1. Identification of specific enhancement goals and user groups affected;
2. Fisheries management concerns and methods;
3. Evaluation plans for fish that are released;
4. Land ownership and potential conflicts; and
5. Site-specific management problems; i.e., beavers, moose, bears, access, snow.

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Roberson, K. Personal Communication. Mr. Roberson is a FRED Division Area Biologist stationed in Glennallen.

APPENDIX

Tentative chum salmon planning assumptions for an egg incubation project designed for 10,000,000 eggs (approximate data).

Assumptions

Age:	2	3	4	5
% return:	0.0	0.1	0.6	0.3

Survival rate; green egg to fry release: 0.5

Survival rate; release to return: 0.01

Fecundity: 2500 eggs per female

Number of fish available: 10,000

Number of ripe females: 4000

First egg take: 1993

Calculations:

Number of eggs	Number of fry	Number of returning adults 1997	1998	1999	total
10,000,000	5,000,000	5,000	30,000	15,000	50,000

Tentative chum salmon planning assumptions for a typical fish hatchery with 10,000,000 design egg capacity (approximate data).

Assumptions

Age:	2	3	4	5
% return:	0.0	0.1	0.6	0.3

Survival rate; green egg to fry release: 0.75

Survival rate; release to return: 0.01

Fecundity: 2500 eggs per female

Number of fish available: 10,000

Number of ripe females: 4000

First egg take: 1993

Calculations:

Number of eggs	Number of fry	Number of returning adults 1997	1998	1999	total
10,000,000	7,500,000	7,500	45,000	22,500	75,000

If fry are fed in net pens in the estuary for 20 - 40 days the survival rate will probably double.
Total number of returning adults would equal 150,000
